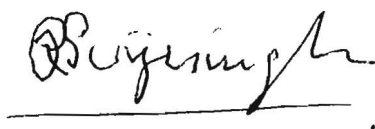


A Study of the Plasma Tweeter

An Honors Thesis (MuMet 495)

By
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A handwritten signature in black ink, appearing to read 'Ranjith Wijesinghe', is written over a horizontal line.

Ball State University
Muncie, Indiana
April 2011

Expected Date of Graduation
May 2011

Abstract

For this project, I studied the plasma tweeter, a non-traditional loudspeaker that is becoming popular in the audiophile and electronics-hobbyist communities. In general, the plasma tweeter involves a visible high-voltage electrical arc that produces sound and can be used to play music. Despite the technical nature of this project, all people can appreciate the novelty of a “singing” electrical arc. Furthermore, the future of loudspeakers may very well rest on plasma tweeter technology if it can be made practical, safe, and affordable for consumers.

To carry out this study, I first found a pre-existing schematic (electronic circuit design) of a plasma tweeter that was appropriate for my skill level, and I used it to build my own plasma tweeter. Interpreting someone else’s design, finding and buying the correct components, and troubleshooting my own circuit were important parts of the construction process. Next, I performed tests on this plasma tweeter to learn more about its capability as a loudspeaker and to find ways to get an optimal sound from it. Throughout this study, I studied the schematic closely to learn the technical concepts behind its operation.

Acknowledgements

I want to thank Dr. Ranjith Wijesinghe for advising me throughout this project, Dr. John Emert for helping with the project proposal and submission process, Dr. Feng Jin for encouraging me to present the project to the public, and Mr. John Decker for providing me with the resources to make my project presentable.

Author's Statement

The traditional loudspeaker is the moving coil speaker. As the name aptly suggests, the traditional loudspeaker involves moving parts: specifically the back and forth motion of a coil and also a cone that is attached to the coil. In general, the rate of oscillation (frequency) and the amount of displacement (amplitude) of these parts is controlled by the variations of the voltage of an input audio signal. The end result is that the motion of the cone compresses and decompresses the air around it producing sound waves for us to hear. This process is known as **transduction** where the electrical energy from an audio signal is converted into acoustic energy for our ears to detect. This conversion is never totally faithful, however. The moving parts of traditional speaker will introduce some form of distortion to the original signal. In other words, the sound we hear from a loudspeaker is never a totally accurate reproduction of the audio signal put through it.

The plasma tweeter has the potential to exceed the traditional loudspeaker in sound quality because it involves no moving parts. Simply speaking, the transduction process of the plasma tweeter involves a high voltage arc that changes the surrounding air temperature based on the voltage of an electrical audio signal. The result is the expansion and contraction of the air that creates sound waves for our ears to hear. The potential for the plasma tweeter lies in the fact that it has no moving parts and so there is a better chance of preventing signal distortion.

The plasma tweeter was worth studying because of its potential for better sound quality. I also undertook this project to apply and practice the knowledge of electronics that I gained from my studies as a Minor in Applied Physics at Ball State. Perhaps the

primary reason for undertaking this study is the novelty of seeing an electrical arc and hearing the music that it can produce.

My understanding of the electrical mechanics of the plasma tweeter came from observing the tweeter, applying my knowledge from BSU electronics courses, and consulting the author of the circuit I have based my project on. The circuit (refer to the Schematic section) is powered by a 12-volt DC source. A flyback transformer steps up this input voltage to form an electrical arc between its output leads. The 555-timer generates a square wave with a center frequency based on the resistance of the potentiometer. The audio signal is used as a control voltage that modulates the frequency of the timer's square wave. The modulated square wave switches a power-MOSFET off and on, and the MOSFET is used to modulate the power of the electrical arc. The fluctuations in power cause fluctuations in surrounding air temperature. This, in turn, causes expansion and contraction of air and sound waves for our ears to hear. In this way, an electrical arc can be used as a speaker that plays music ("Simple Plasma Tweeter").

Imitating someone else's work was an effective way for me to practice my knowledge while also learning new things. It has allowed me to practice what I have learned from my studies of electronics, to learn about new technology that is becoming increasingly popular, to critically respond to the issues of replicating someone else's work, and experience the novelty of a "singing" electrical arc without having to design my own circuit. I learned many practical things like how to use a flyback transformer as well as conceptual things like how sound waves can be created with air temperature variations.

Once I gained a comfortable understanding of the circuit, I was free to interpret and critically assess the existing design and contribute my own ideas to the project. This was

where I tested the circuit with a function generator and observed its response to varying frequencies and amplitudes of sine tones. The results of these tests led me to involve my prior knowledge of audio to improve what I viewed was a shortcoming to the original design at least in my particular realization of it. The use of an audio mixer was used to amplify and filter the input audio signal in such a way that promoted increased steadiness and clarity in the sound coming from the plasma tweeter. Even with such increases, however, the plasma tweeter of this project is not yet suitable to replace conventional sound speakers: it is not as accurate, loud, steady, or clear.

In the end, although much was learned through imitating, assessing, and contributing to someone else's work, I do recognize that the next logical step in the process is innovation. However, new ideas do not just materialize out of thin air, but innovation requires the synthesis of pre-existing ideas to create something strong and stable. Perhaps a future project could be to extend my study to include other more complex designs. Then, there would be a need to synthesize the strengths and weed out the impracticalities of plasma tweeter technology as a whole. Maybe then someday there could be a future for plasma tweeters in the living rooms of all audio consumers. At least in this project I have gained a taste of the novelty of a "singing" electrical arc.

Supplements

I have included a data CD containing videos of significant stages of the project.

Video 1 shows the plasma tweeter after initial construction and debugging. Video 2 shows me demonstrating the tests I performed on the plasma tweeter to learn how to improve its functionality. Video 3 shows me elaborating on the improvements of the tweeter's functionality as a result of applying the information from those tests. QuickTime software, available for both Mac and PC formats, is required to playback these videos on a computer. Below is a link to QuickTime's download site.

<http://www.apple.com/quicktime/download/>

Works Cited

The schematic and some information on how the tweeter works were gathered from the following web source. Most of my understanding of this particular plasma tweeter comes from studying the schematic and observing its function in real life.

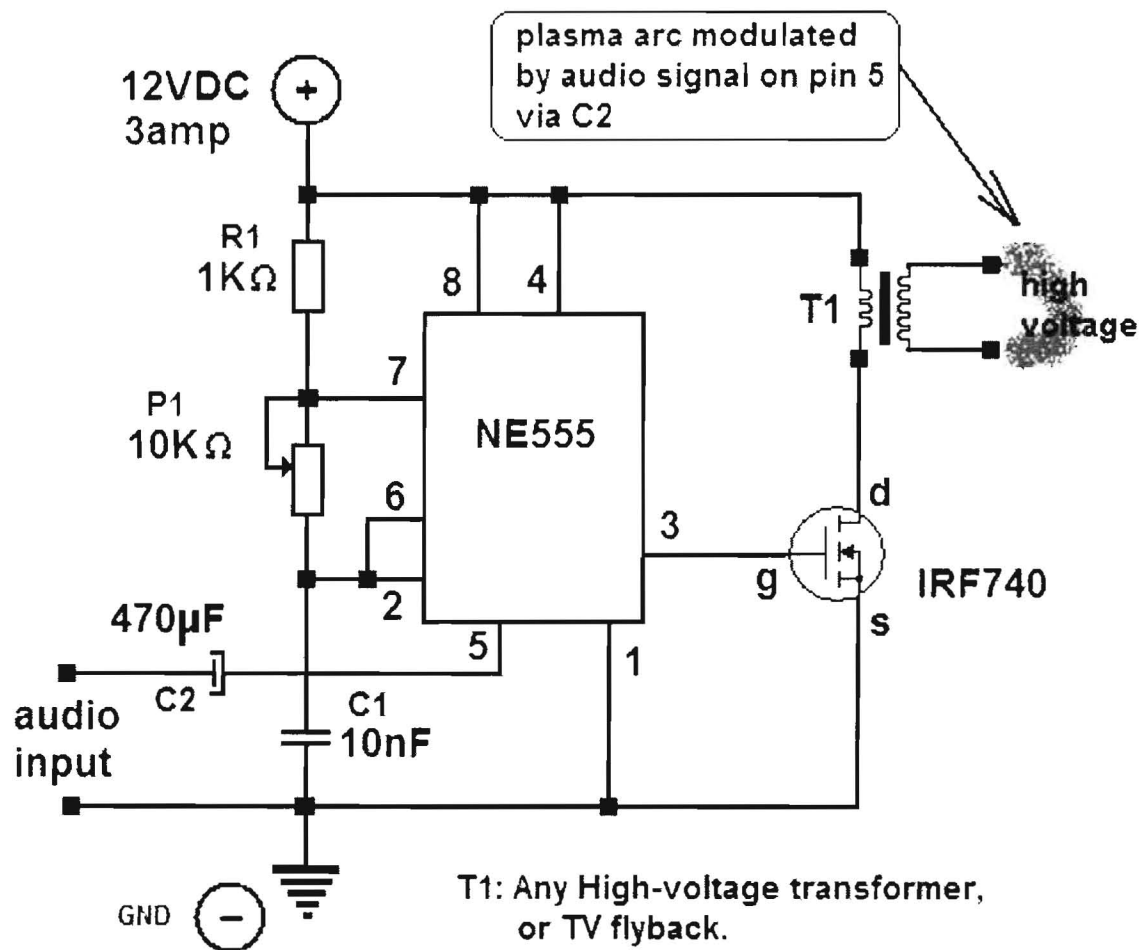
"Simple Plasma Tweeter."

<<http://webpace.webring.com/people/gl/lemagicien/hvpage/pltwetter/pltwetter.html>>. Accessed on 12/20/2010. Author's e-mail: <lemagicien@email.com>.

"Plasma Tweeter." <<http://www.angelfire.com/electronic/cwillis/tweeter.html>>.

<Accessed on 11/14/2010>.

The Schematic



T1: Any High-voltage transformer,
or TV flyback.
Primary about 10-20 turns

P1 set at 1.6 Kohm
NE555 freq = 32 KHz

("Simple Plasma Tweeter")

Project Journal

1/28/11 –

I have already invested a lot of time, money, and energy into this project. Much has happened since I have decided to do this project last semester. First, I bought almost all the components I would have needed to construct a plasma tweeter circuit I found on the Internet by an electronics enthusiast as far as I know. I have included the URL to his site in the works cited. After realizing that the complexity of this circuit would most likely overwhelm me with debugging problems so that I may never get anything done, I decided to look for simpler circuits.

Even though I am reproducing the work of others, this does not make the task of building something as uncommon as a plasma tweeter as simple as a walk in the park, even with a supposed simple design. Anyway, I found a simpler circuit put on the web by an unnamed author, but it is a circuit that seems to be regarded by most electronics hobbyists as the most simple of the plasma tweeter designs. I have seen this circuit in at least two separate online sources including a video confirming the circuitry and functionality of this particular design. I have posted schematic, parts list, and URL to the website I found the circuit on in the appendix.

Most of the parts were easy to find and purchase from either Newark or Mouser, online components distributors. One part that was particularly hard to find was the high voltage (HV) step-up transformer. It seems HV transformers are not commonly used, so electronics hobbyists in need of one either have to wind one themselves (requiring thousands of hand-winds) or salvage them from old TVs or car ignition systems. I easily found a car ignition coil for cheap, and today I used it to complete my first attempt at the simple plasma tweeter circuit.

Other things to note before I explain the events of this first attempt: I am using a CD player as an audio source, a breadboard to make all my connections, and alligator clips to

found a car ignition coil for cheap, and today I used it to complete my first attempt at the simple plasma tweeter circuit.

Other things to note before I explain the events of this first attempt: I am using a CD player as an audio source, a breadboard to make all my connections, and alligator clips to connect components with breadboard-unfriendly connectors. These include the potentiometer, the transformer contacts, and the MOSFET.

Today, I failed to make a stable arc and the arc I could intermittently sustain was no more than a millimeter. I also failed to “produce music” with the arc I could create. The first component to blame was the transformer. I checked to see if the transformer was working properly by connecting it directly to a 12-volt power supply. I used a multi-meter to measure the voltage across the secondary and...there was no stepped up high DC voltage as one would expect from an HV transformer. The multi-meter did show a high AC voltage, but does this make sense if I am not putting an AC signal across the primary? It does not register. I will ask my advisor and report his suggestion later; in the meantime, I am buying a flyback transformer – this is an HV transformer used in television sets.

2/03/2011 –

The flyback transformer worked! I got the electric arc to form at several millimeters and...it played music! Despite this success, I already see much room for improvement. For example, the music is highly distorted and can barely be heard above the crackle of the electrical arc. I plan on putting sine tones through the circuit in order to test two theories of mine based on prior knowledge and observation: 1) that the lower frequency content of a full bandwidth signal is what is causing the distortion and 2) that the level of the voltage

outputted by the iPod is not high enough to modulate the electrical arc effectively. After doing several tests, I hope to figure out what my next move will be. I also want to try decreasing the area of contact for the arc. Right now, the arc needs to form between the relatively large contact area of the suction cup lead (on the flyback transformer) and the wire of my negative lead. Perhaps if I decrease this area of contact, the arc will be more stable and less distorted.

I made a video of today's success, and I plan on taking pictures in the future to document my progress.

2/17/2011 –

I have used a function generator to test the frequency and amplitude response of the plasma tweeter. The tweeter seems to have a range of about 200 to 2000 Hz where the pitch of the periodic signal is audible. Beyond that, it is possible to discern pitch, but with more trouble. The “clearness” of the plasma tweeter’s acoustics improves with increase in the input signal’s amplitude. The benefit of increasing the input signal’s amplitude seems to level off around 2 volts from the function generator. With these two discoveries in mind, perhaps amplifying the signal from the iPod and filtering out low and high frequencies before putting it through the plasma tweeter will enhance clarity. I will make a video demonstrating my discoveries with the function generator. I have decided that using video documentation of this project will be an effective way of delivering its results. My next step is to bring in an audio mixer and using its amplifier and EQ to modify the signal from my iPod.

Also, it seems decreasing the area of contact between the positive and negative leads does not have a significant effect on clarity. It seems more effective to decrease the amount of connecting wire. Since my project is abounding in alligator clips to hook up components, this may be one of the complications I am facing. I will make an effort to clean up my connections as well.

3/3/2011 –

I have added a Mackie audio mixer between my input signal and the circuit. I use it to filter out high and low frequencies and supply input signal pre-amplification. This tactic has worked favorably for the overall functionality of the plasma tweeter circuit. The output signal is steady and probably as clear as I will ever be able to make with the components and design I am working with. I will make a video demonstrating this recent improvement to my version of the plasma tweeter circuit.

Ideally, instead of an audio mixer there should be a pre-amplifier and filter built directly into the circuit. Unfortunately, it looks as if time might be running out for me to make such improvements. I still have to write a formal report on the project as well as learn the specific technicalities behind the circuit's operation as it stands now.

Perhaps the only other improvement I can now make to this project is to reorganize the circuit components so that it is presentable as well as use some sort of helping hands mechanism to hold the output leads in an appropriate position. This will take some time, and then the remaining time I should spend writing my formal report. Also, one of my physics professors has asked me to give a small presentation of my project and I will need time to prepare for that as well.

Appendix

I have attached all the receipts of purchases I made in pursuit of this study.



Federal Tax I.D. No:
35-1167154

**INVOICE**

CURRENCY: U.S. Dollar
INVOICE NO: 20005203
INVOICE DATE: 01/12/11
ACCOUNT NO: 395462
P.O. NO: 400267352
P.O. REL. NO:

0350 395462 20005203 0000186 0001130 0000002847 9

Kalalau Cantrell
Kalalau Cantrell
615 N. Dicks St. Apt. 12
Muncie IN 47303

REMIT TO:

Newark
P.O. Box 94151
Palatine IL 600944151



Check Box to change address or payment information

DO NOT PAY

Federal Tax I.D. No:
35-1167154

SHIP TO: Kalalau Cantrell
Kalalau Cantrell
615 N. Dicks St. Apt. 12
MUNCIE
IN
47303

ORDERED BY: Kalalau Cantrell
INVOICE NO: 20005203
INVOICE DATE: 12-Jan-2011
ACCOUNT NO: 395462
P.O. NO: 400267352
P.O. REL. NO:
DATE SHIPPED: 12-Jan-2011
CARRIER DESCRIPTION: USPS Priority Mail
ORDER NO./PACKING SLIP: 49619
PAYMENT TERMS: Cr Card

Questions about your order? Call Newark Sales Representative at: 1-800-4-NEWARK CUSTSERV@NEWARK.COM

Invoice Details

Quantity	Newark Stock No.	Description	Unit of Measure	Quantity Shipped	Quantity B/O	Unit Price	Extended Price
<i>Customer Part Number & Description appears directly under each item</i>							
3	58K1738	IRF740B N CHANNEL MOSFET 400V 10A TO-220; Transistor Polarity:N Channel; Continuous Drain Current Id:10A; Drain Source Voltage Vds:400V; On Resistance Rds(on):0.54ohm; Rds(on) Test Voltage Vgs:10V; Threshold Voltage Vgs Typ:4V	EA 00001	3	0	1.090	3.27
CUST PO LINE#: 001							
3	25M9068	ECA1HMR47 CAPACITOR ALUM ELEC 0.47µF 50VDC RADIAL; Capacitor Dielectric Type:Aluminium Electrolytic; Capacitance:0.47µF; Capacitance Tolerance:± 20%; Voltage Rating:50VDC; Life Time @ Temperature:2000 hours @ 85°C; Height:11mm; Diameter:5mm	EA 00001	3	0	0.094	0.28
CUST PO LINE#: 002							
3	14M6720	2222 138 36471 CAPACITOR ALUM ELECT 470UF 25V AXIAL; Capacitor Dielectric Type:Aluminium Electrolytic; Capacitance:470µF; Capacitance Tolerance:± 20%; Voltage Rating:25V; ESR:0.44ohm; Series:AML 138; Life Time @ Temperature:10000 hours @ 105°C	TC 00001	3	0	2.620	7.86
CUST PO LINE#: 003							
3	46M2510	P231-FC20BR10K POT ROTARY 10KOHM 20% 500mW; Track Resistance:10kohm; Track Taper:Linear; No. of Turns:1; Resistance Tolerance:± 20%; Voltage Rating:500V; Series:P231; Power Rating:500mW; Adjustment Type:Side; Rotation Electrical Angle:270°	EA 00001	3	0	1.300	3.90

CUST PO LINE#: 004
Tracking Number(s): 03101230000183312358 03101230000183315915

Mdse Total:	15.31	Sales Tax:	1.86	Freight:	11.30	Invoice Total:	28.47
Account Statement							
Current	30 Days	60 Days	90+ Days	Invoice Amount Due:		Paid by Visa Card	
0.00	0.00	0.00	0.00				

Newark's Credit Department is here to help:
CALL CREDIT CARD HOTLINE - 773/907-5740

Newark InOne is now Newark. We do more for you, so you
can do more with your day.